CITRA

KUWAIT

5G-Advanced & AI Era

Strategic Whitepaper

Vision 2026 — Network Intelligence, Indoor 5G-A Rollout & AI-Enabled Telecommunications Governance

100%	1.2M+	#1	3,000+
5G Population Coverage	Active 5G-A Subscribers	Global 5G Speed Ranking	5G-A Sites Deployed

Prepared by: CITRA Kuwait — General Authority for Communications and Information Technology

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Table of Contents

Preface

Kuwait stands at a historic inflection point. As the nation that achieved #1 global ranking in 5G adoption — with 100% population coverage, 4.12 million 5G subscribers, and a 68%+ 5G traffic ratio — Kuwait now sets its sights on an even more ambitious horizon: becoming the world's first 10 Gbps mobile nation by 2028 and claiming the #1 global position on the Ookla Speedtest Index.

This whitepaper, issued by the Communication & Information Technology Regulatory Authority (CITRA), charts Kuwait's strategic path from the commercially launched 5G-Advanced (5G-A) networks of today through a precisely defined spectrum roadmap to 6G readiness by 2030–2035. It does so in the context of the most significant technological transformation in a generation: the convergence of next-generation connectivity with artificial intelligence.

The AI era is not approaching — it has arrived. AI smartphones, AI glasses and XR headsets, AI-enabled vehicles, and autonomous robots are already reshaping the demand profile for mobile networks. 5G-A, with its AI-native Radio Access Network (RAN) capabilities introduced in 3GPP Release 18–20, is precisely engineered to serve this new generation of intelligent devices.

> **Kuwait's Four National Aspirations**
>
> 1. World's First 10 Gbps Mobile Nation (2028) • 2. #1 Global Ookla Speedtest Ranking (Downlink and Uplink) • 3. 80% 5G-A Coverage — Indoor and Outdoor • 4. 50%+ 5G-A Activated Users

CITRA has identified indoor coverage as a key area for development to achieve our national targets. While Kuwait has successfully deployed over 3,000 outdoor 5G-A sites, the next phase of growth focuses on bringing 5G-A capabilities indoors—where 70–80% of mobile traffic currently originates. This whitepaper dedicates a full chapter to the indoor 5G-A program, establishing it as a coverage priority and the primary pathway to securing the #1 Ookla global ranking

Kuwait Vision 2035 — 'New Kuwait' — defines a $193 billion national transformation across seven strategic pillars. Every one of these pillars has a direct dependency on connected intelligent infrastructure. 5G-A and AI are not supporting elements of Vision 2035; they are its execution engine. CITRA's mandate in this strategic era extends beyond spectrum allocation and network oversight to encompass AI governance, data sovereignty, indoor coverage regulation, and the creation of an innovation ecosystem that positions Kuwait as a regional technology leader, global connectivity benchmark, and a nation where Vision 2035's aspirations are delivered through world-class digital infrastructure.

This whitepaper is structured to serve multiple audiences: policymakers and regulators who will shape Kuwait's digital infrastructure framework; telecommunications operators who will invest in and deploy next-generation networks; enterprises and sectors that will build on this connectivity foundation; and the broader public who will ultimately be the beneficiaries of a world-class digital Kuwait.

Executive Summary

Kuwait stands at the frontier of the global digital economy. With 100% 5G population coverage, and one of the world's first commercial 5G Advanced networks, and an ICT sector growing from $22.5 billion to $39.8 billion by 2029, Kuwait's connectivity leadership is unmatched. CITRA's National Connectivity Strategy 2025–2035 is the technical execution plan for Kuwait Vision 2035 — charting a ten-year journey from 5G-A commercial pioneer to the world's first 10 Gbps mobile nation, from AI-enabled network infrastructure to a fully connected society where every hospital, school, government building, and business district operates at peak 5G-A performance.

01	02	03	04
World's First 10 Gbps Nation	#1 Global Ookla Ranking	80% 5G-A Coverage	50%+ 5G-A Activated Users
Delivering by 2028	Currently Ranked #3	Indoor Program: 2026	Growing from 1.2M Today

Kuwait's 5G-A Leadership: Key Metrics 2026

#1	100%	4.12M	68%+	1.2M+	$22.5B
Kuwait Global 5G Rank	Population 5G Coverage	Subscribers 5G Users	% of Total 5G Traffic	& Growing 5G-A Activated	To $39.8B by 2028 ICT Market

CITRA's 2025–2035 Strategic Agenda

CITRA's mandate for the decade ahead is structured around six interlocking strategic initiatives, each directly enabling Kuwait Vision 2035 and each building on Kuwait's established position as the GCC's most advanced 5G nation.

01 Spectrum Leadership 5-Phase Roadmap to 10 Gbps	CITRA's structured five-phase spectrum strategy progresses from today's 3 Gbps 2CC platform to 10 Gbps five-carrier aggregation by 2028, culminating in 6G Pioneer status by 2035. Each phase is calibrated to maintain Kuwait's position at the leading edge of global commercial 5G-A deployment.
02 National Indoor 5G-A Program IBS Framework: 2026 Launch	CITRA is pioneering Kuwait's first mandatory Indoor Building Solution (IBS) regulatory framework — delivering 5G-A quality inside every hospital, airport, government building, shopping center, and high-density venue. As 70–80% of mobile data is generated indoors, this program directly unlocks Kuwait's path to the Ookla #1 global ranking and serves as the indoor foundation for Vision 2035's healthcare, infrastructure, and living environment pillars.

03 AI-Native Network Intelligence AI-RAN, Edge Computing & Automation	CITRA is deploying an AI governance and technical framework that transforms Kuwait's network from managed infrastructure into an intelligent, self-optimizing system. AI for Nework, multi-access edge computing (MEC), and autonomous network operations (TMForum L4) reduce OPEX, optimize spectrum usage in real time, and deliver ultra-low latency processing at the network edge — enabling use cases from autonomous vehicles to real-time medical imaging.
04 AI & Data Governance National Framework for AI Accountability	CITRA's five-pillar AI governance architecture — covering data sovereignty, algorithmic accountability, AI safety standards, cross-sector regulation, and international alignment — positions Kuwait as a responsible AI-adopting nation. This framework protects citizens, enables industry, and establishes Kuwait as the GCC's benchmark for AI regulatory leadership alongside spectrum management.
05 Industry & Society Enablement 10 Sectors: Healthcare to Smart Cities	5G-A is the connectivity backbone for Kuwait's economic diversification. CITRA's strategy enables precision healthcare with AI diagnostics and remote robotic surgery; immersive 5G-A-powered education; intelligent oil & gas operations; autonomous ports; smart city infrastructure for South Saad Al-Abdullah and beyond; AI-driven financial services; XR retail; connected transport; and AI-enabled public safety. Each sector represents both a citizen quality-of-life improvement and a direct contribution to Vision 2035's economic diversification mandate.
06 Fixed-Mobile Convergence Dual 10 Gbps by 2028: GPON + 5G-A	The Beyon PPP fiber program (February 2026) delivers 10 Gbps GPON to Kuwaiti homes and businesses, converging with 5G-A mobile to create a unique dual-10 Gbps ecosystem. This fixed-mobile convergence — unmatched globally — means Kuwait will simultaneously achieve 10 Gbps fixed broadband and 10 Gbps mobile by 2028, providing the infrastructure foundation for every industry, service, and citizen application envisioned in Vision 2035.

Kuwait: Building the World's Most Connected Nation

One of the First countries in 5G and 5G-A. The world's first 10 Gbps mobile nation by 2028. From the pioneers to mandate indoor 5G-A coverage. A national AI governance framework that protects and enables. 5G-A powering every hospital, every school, every smart city, every port — the infrastructure backbone of New Kuwait 2035. This is CITRA's mandate, and this whitepaper is its execution roadmap.

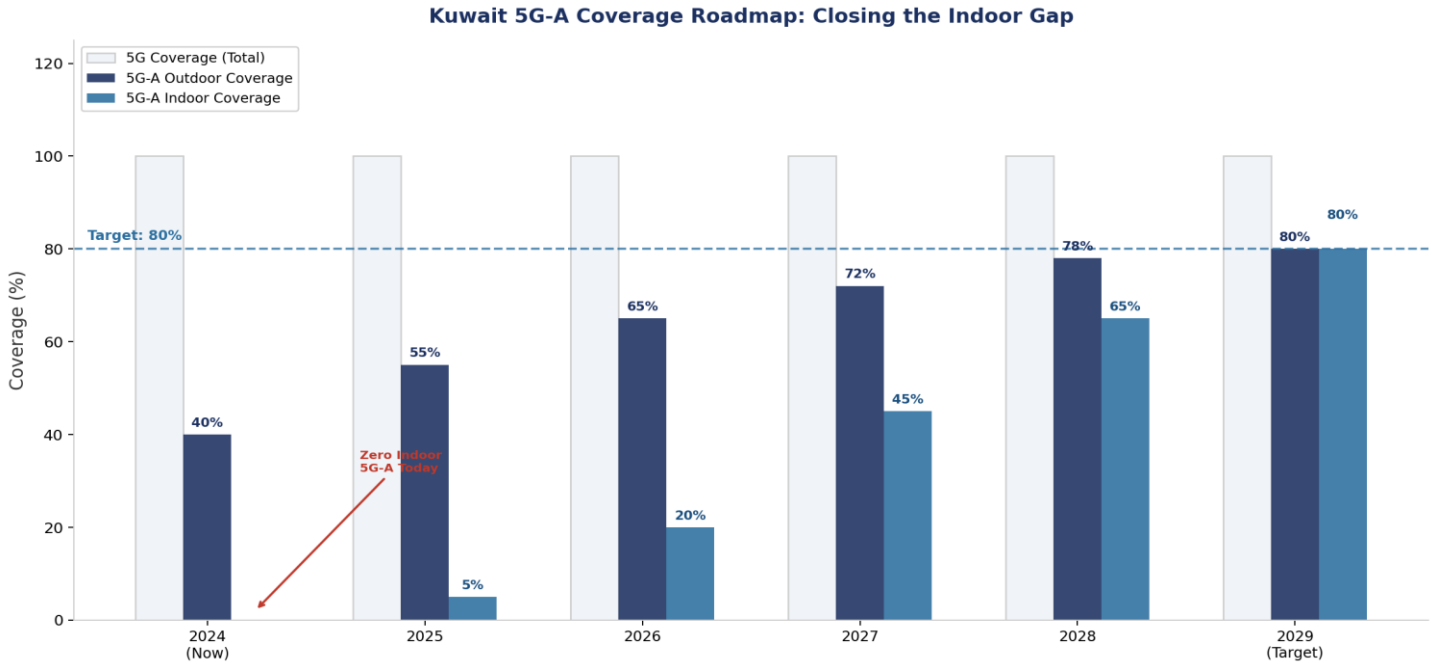

Figure 1 | Kuwait 5G-A Coverage Roadmap 2024–2029: From Outdoor Excellence to Indoor Ubiquity

Spectrum Roadmap: The Technical Engine

Kuwait's path to 10 Gbps and beyond is anchored in a five-phase spectrum strategy, each phase unlocking a step-change in national connectivity capability:

- Phase 1 (2024–2025): 190–200 MHz per operator (C-band + 2.3/2.6 GHz). Commercial 5G-A with 2CC carrier aggregation. Peak ~3 Gbps.
- Phase 2 (2026–2027): Deployment of 3.8–4.1 GHz mid-band (Q4 2026 licensing). ~300 MHz per operator. 3CC aggregation. Peak ~5 Gbps. Indoor 5G-A program launches.
- Phase 3 (2028): Deployment of Upper 6 GHz (6425–7125 MHz). ~500 MHz per operator. 5CC aggregation. Peak ~10 Gbps. World's First 10 Gbps Nation declaration.
- Phase 4 (2029–2031): mmWave (24/26/28/39 GHz). >1,000 MHz per operator in ultra-dense zones. Peak 20+ Gbps for hotspots, stadiums, enterprise campuses.
- Phase 5 (2030–2035): 6G (IMT-2030). Upper 6 GHz and potential extend lower 7GHz spectrum. AI-native air interface.

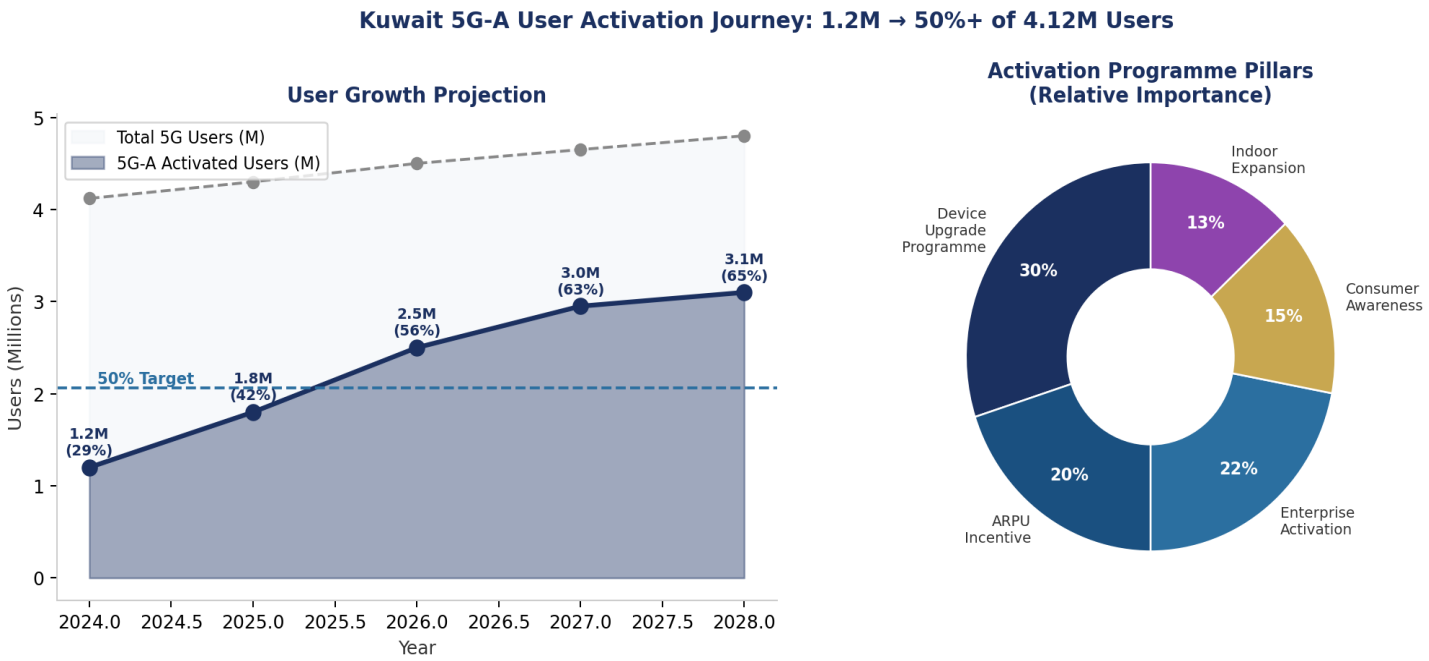

Figure 2 | Kuwait 5G-A User Activation Journey: Converting 4.12M 5G Users to 5G-A

CH 2 The AI Device Revolution
Mobile AI Era

Kuwait Vision 2035: 5G-A & AI as the National Mandate

On 30 January 2017, His Highness the Amir launched Kuwait Vision 2035 — branded "New Kuwait" — a comprehensive national transformation plan to build Kuwait into a financial, cultural, and institutional leader in the region. Structured around seven strategic pillars and encompassing 164 programs, projects, and initiatives, the Vision governs a $193 billion active development pipeline. Every pillar of this national transformation depends, directly and fundamentally, on a single enabling infrastructure: connected, intelligent, high-capacity digital networks.

5G-A is not a telecommunications product. It is the nervous system of New Kuwait. AI is not a technology experiment. It is the intelligence layer that converts connectivity into capability. Together, they transform Vision 2035 from aspiration into execution — from the digital hospital room to the smart city street, from the e-government portal to the automated port terminal, from the immersive classroom to the globally connected financial hub.

> **Kuwait Vision 2035 — "New Kuwait": At a Glance**
>
> Launched: January 2017 | Pillars: 7 Strategic | Programs: 164 Initiatives | Project Pipeline: $193 billion active | ICT Market: $22.5B (2023) → $39.8B (2029) | Smart City Investment: $27.6B (South Saad Al-Abdullah) | Healthcare Budget: $10B/year (11% of national budget) | Digital Health Allocation: $200M | 5G Population Coverage: 97% | Internet Household Penetration: 99.4%

V2035.1 The Seven Pillars: 5G-A & AI Enablement Matrix

The table below maps each of the seven Vision 2035 pillars to its strategic goal and the specific 5G-A and AI capabilities that directly enable that goal. CITRA's national 5G-A strategy is the technical expression of this mapping.

Vision 2035 Pillar	National Goal	5G-A & AI Enablement
1. Effective Public Administration	Digitize government services; transparent, accountable, AI-powered public service delivery; mobile-first citizen access	Mobile-first government kiosks and apps at 10 Gbps; AI processing of citizen requests and automating approvals; digital identity verification; 5G-A-connected smart regulatory systems across all government buildings requiring indoor coverage
2. Diversified Economy	Reduce oil dependency (currently 90% of revenue); grow ICT market from $22.5B	5G-A is the platform layer of the digital economy: enables Industry 4.0 automation, AI-driven fintech at scale, digital commerce, logistics robotics, and

	to $39.8B by 2029; expand private sector employment by 69%	real-time supply chain intelligence. Every new non-oil economic sector — from XR retail to autonomous ports — requires 5G-A as its foundation
3. Developed Infrastructure	$27.6B South Saad Al-Abdullah smart city (400,000 residents); intelligent transport; digital utilities; IoT-managed municipal services; 15% renewable energy by 2030	5G-A provides the wireless backbone for all smart city IoT: 200+ cameras/km for AI traffic management, connected smart meters and grid sensors, autonomous vehicle corridors, and 5G-A private networks for industrial and utility sites. No smart city is viable without 5G-A indoor coverage in its commercial and residential cores
4. Sustainable Living Environment	Air quality monitoring stations; smart waste management; eco-friendly buildings; renewable energy complexes; sustainable urban planning aligned with Vision 2035 environment targets	Always-on 5G-A IoT connectivity for real-time environmental sensor networks across Kuwait City; AI-driven air quality analytics and early warning systems; smart waste routing using connected bin sensors; 5G-A building automation reducing energy consumption 30–40% in smart-connected facilities
5. Healthcare	$10B annual budget (11% of total national budget); $200M digital health investment; AI diagnostics at Jaber Hospital; telemedicine rollout; AI healthcare market reaching $1.15B	10 Gbps 5G-A enables: 4K/8K medical imaging transmission in real time; sub-1ms URLLC for remote robotic surgery (piloted at Jaber Hospital); AI triage via ambulance-to-hospital 5G-A-connected vitals monitoring; hospital private 5G-A networks for IoT medical devices; nationwide telemedicine without quality degradation. Indoor 5G-A coverage in every hospital is a prerequisite for Health Vision 2035
6. Human Capital & Education	Complete education system reform toward a knowledge-based economy; competitive, productive workforce; national digital skills development program; AI-literate graduates by 2035	5G-A enables immersive AR/VR learning at full 10 Gbps quality; real-time AI-personalized curricula adapting to each student; equal-access remote education without bandwidth compromise; digital labs and connected campuses. AI tutoring systems, enabled by 5G-A's low latency, deliver personalized instruction at scale across all governorates
7. Strengthened Global Position	Transform Kuwait into a regional financial, cultural, and institutional leader; enhanced international standing in diplomacy, trade, innovation, and technology leadership	Kuwait to sustain #1 rank in ICT Development Index (IDI) and achieve #1 Ookla global ranking signals digital sovereignty to international investors and partners. A pioneer nation to deploy 5G-A commercially positions Kuwait as a technology innovation hub in the GCC. AI centers of excellence enabled by 5G-A's compute infrastructure attract global technology investment aligned with Vision 2035's global positioning objective

V2035.2 CITRA: The Regulatory Engine of New Kuwait

CITRA's mandate under Vision 2035 extends far beyond spectrum licensing and network oversight. As the regulatory body responsible for the ICT infrastructure that underpins all seven Vision 2035 pillars, CITRA occupies a uniquely cross-cutting role: every national digital ambition — from e-government to smart cities, from digital health to AI governance — is only achievable if CITRA delivers the connectivity foundation on schedule, at the right quality, and at the right coverage.

CITRA Regulatory Action	Vision 2035 Pillars Unlocked
5G-A spectrum phases 1–5 (2025–2035)	Infrastructure ■ Economy ■ Healthcare ■ Education ■ Global Position — every digital sector requires progressively higher spectrum capacity
Indoor Building Solution (IBS) mandate	Healthcare (hospital coverage) ■ Public Administration (government buildings) ■ Living Environment (smart buildings) ■ Economy (commercial malls, offices, hotels)
AI & Data Governance Framework	Healthcare (AI diagnostics regulation) ■ Economy (AI fintech, autonomous vehicles) ■ Public Administration (AI government services) ■ Global Position (sovereign AI capability)
Ookla #1 Quality Benchmark Program	Global Position (international rankings) ■ Economy (attracting digital investment) ■ Living Environment (citizen quality of life indicator)
Neutral Host / Infrastructure Sharing Framework	Infrastructure (cost-efficient smart city coverage) ■ Healthcare (hospital 5G-A coverage) ■ Economy (reduced deployment cost, faster rollout)

> The CITRA Mandate: Enabling New Kuwait

Kuwait Vision 2035 allocates over 11% of national investment to modern infrastructure. The ICT layer — governed by CITRA — is the enabler of all other infrastructure. A port cannot be autonomous without 5G-A connectivity. A hospital cannot deliver AI diagnostics without indoor 5G-A coverage. A smart city cannot optimize energy without IoT sensors on a 5G-A network. CITRA's 5G-A national strategy is, in the most direct sense, Kuwait's Vision 2035 execution plan for digital infrastructure.

CH 1 **5G-Advanced Technology**
Architecture, Capabilities & Evolution

5G-Advanced Technology: Architecture, Capabilities & Evolution

5G-Advanced (5G-A) represents the evolutionary enhancement of 5G standardized through 3GPP Releases 18, 19, and 20. It is not a new generation but a qualitative leap within the 5G framework — one that introduces AI-native capabilities, significantly enhanced spectrum efficiency, and the technical foundations for the AI device era.

1.1 The 3GPP Standards Journey: R15 to R20

Release	Timeline	Key Features	Significance
R15	2019	5G NR foundation, NSA/SA modes, eMBB	5G launch standard
R16	2020	URLLC, V2X, network slicing, RedCap	Industrial 5G
R17	2022	Satellite integration, IoT optimization	Extended coverage
R18	June 2024 (frozen)	5G-A: AI/ML RAN, Multi-CC aggregation, XR optimization, Network-controlled repeaters	5G-A launch standard — Kuwait commercial today
R19	2025	Advanced carrier aggregation (4-5CC), Enhanced AI beamforming, RedCap Evo	Peak efficiency
R20	2026–27	6G case study phase and consensus building, AI-native air interface, Ambient IoT	Bridge to 6G
R21	2028-2029	6G standard specification definition,	First 6G commercial version

1.2 Six Core 5G-A Enhancements

Multi-Carrier Aggregation (MCA)

The foundational speed multiplier of 5G-A. By aggregating multiple spectrum bands simultaneously, peak data rates scale proportionally with spectrum width. Kuwait's operators currently deploy 2CC

(C-band + 2.3/2.6 GHz), with the roadmap to 3CC (adding 3.8–4.1 GHz in 2026) and eventually 4–5CC with Upper 6 GHz (2028).

- 2CC (2024): ~3 Gbps peak — Commercial 5G-A baseline
- 3CC (2026): ~5 Gbps peak — Phase 2 target with 3.8–4.1 GHz
- 4CC–5CC (2028): ~10 Gbps peak — World's First 10 Gbps Nation

AI for Network (3GPP R18)

For the first time in mobile standards, artificial intelligence is embedded as a native function in the Radio Access Network — not as an overlay, but as a core architectural element:

- AI Beam Management: Predictive antenna beam steering based on user trajectory models, reducing handover failures by up to 40%
- AI Channel Estimation: Machine learning-based signal processing improving throughput in dense urban environments by 15–25%
- AI Interference Management: Coordination across cells using AI to suppress co-channel interference in multi-operator environments
- Predictive Handover: AI-driven pre-emptive resource allocation reducing end-to-end latency below 1ms for edge use cases

XR (Extended Reality) Optimization

5G-A introduces dedicated XR traffic handling — separate QoS frameworks for Mixed Reality (MR), Virtual Reality (VR), and Augmented Reality (AR) streams requiring simultaneous high-throughput downlink and high-reliability uplink. This is the technical foundation for AI glasses and XR headsets.

RedCap (Reduced Capability) and Ambient IoT

5G-A defines a tiered device capability framework: RedCap devices (wearables, industrial sensors) with reduced complexity and cost, and Ambient IoT devices in R18 that require no battery — harvesting energy from ambient signals. This enables the mass deployment of Kuwait's smart city and logistics IoT infrastructure.

Advanced Sleep Mode and Green RAN

AI-driven base station sleep modes in 5G-A achieve 15–30% reduction in network energy consumption without service quality degradation — enabling Kuwait's Green 5G-A Program to reduce operator carbon footprint while expanding network capacity.

1.3 Spectrum Layers: The Architecture of Speed

5G-A operates across three spectrum layers, each serving a distinct role in the network architecture. A critical consideration for Kuwait's indoor program is that these layers have different building penetration characteristics — lower frequencies penetrate buildings better, with significant implications for indoor coverage design:

Layer	Bands	Role	Typical Range
Coverage	700 MHz, 900 MHz, 2.1 GHz	Rural, indoor penetration, broad coverage	5–15 km
Capacity	C-band (3.5–4.2 GHz), 2.3/2.6 GHz	Urban capacity, 5G-A primary layer. Note: 2.3/2.6 GHz has 3.6 dB better building penetration than C-band	300–1000m
Ultra-speed	Upper 6 GHz	10Gbps nationwide capacity layer, extremely large aperture array (ELAA) enable U6G same coverage ability with C-band	300–1000m
	mmWave (28 GHz)	Hotspots, stadiums, 10 Gbps zones	50–200m

CH 2 The AI Device Revolution
Mobile AI Era

The AI Device Revolution: Mobile AI Era

The convergence of 5G-A and on-device artificial intelligence is creating an entirely new category of connected products — devices that do not merely transmit data, but intelligently process, generate, and act upon it at the edge. This chapter examines the four primary AI device categories reshaping network demand and the CITRA regulatory implications for each.

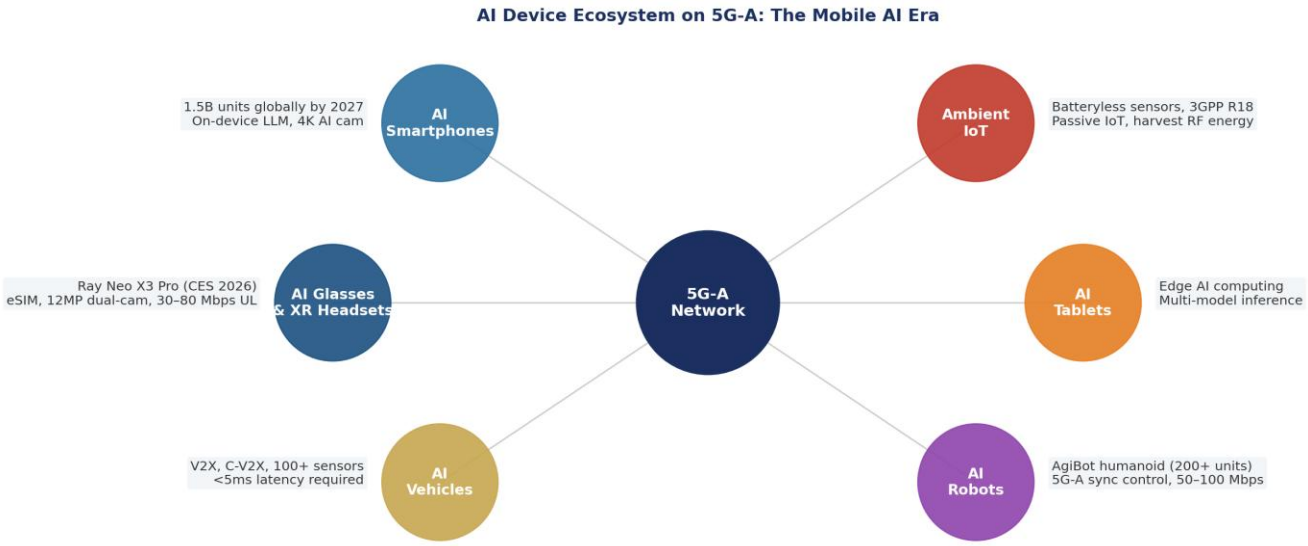

Figure 3 | AI Device Ecosystem on 5G-A: The Mobile AI Era

2.1 AI Smartphones

The AI smartphone represents the largest near-term device category — with Samsung Galaxy AI, Apple Intelligence, and equivalents from Huawei, Xiaomi, and Google integrating on-device neural processors (NPUs) capable of 20–35 TOPS (Tera Operations Per Second). Globally, AI smartphone shipments are forecast to reach 1.5 billion units by 2027.

AI Smartphone Feature	5G-A Network Requirement	Kuwait Impact
Real-time generative AI (text, images)	Low latency <20ms, sustained downlink 100+ Mbps, uplink 10Mbps	~4.12M potential users
AI photography & video (8K)	High uplink capacity for cloud sync	Consumer ARPU uplift
Live translation, voice AI	<10ms latency, edge AI inference	Cross-language services

On-device large language models	Intermittent high-bandwidth sync	Minimal cloud dependency

2.2 AI Glasses and XR Headsets

The most demanding 5G-A device category from a network perspective. Apple Vision Pro (spatial computing), Meta Ray-Ban AI Glasses, and competing platforms require simultaneous high-resolution video downlink (50–100 Mbps per eye), near-zero latency uplink for gesture and camera data, and sustained connectivity for cloud AI inference. The defining characteristic of AI glasses is that they are always-on visual devices: their dual cameras continuously stream real-world data to on-device and cloud AI.

- Field of View rendering: 4K per eye at 90 fps = ~200 Mbps aggregate downlink for full XR immersion
- Camera configuration: Dual 12MP RGB cameras (Sony IMX681-class sensors) + depth sensor for AR spatial mapping
- Live streaming uplink: 30–80 Mbps sustained uplink required for first-person view (FPV) live broadcasting from AI glasses to cloud/viewers
- Haptic/spatial audio sync: requires <2ms round-trip latency for natural interaction feel
- Cloud AI offload: NPU-to-cloud inference via MEC reduces latency from 50ms (public cloud) to 1–3ms — essential for real-time scene understanding
- Battery constraint: continuous 5G-A connection drawing <150mW per device; 4G-class devices use ~70mW

> **Ray Neo X3 Pro — CES 2026 Launch**
>
> The Ray Neo X3 Pro (unveiled CES January 2026) represents the first mass-market phone-free AI glasses: eSIM + 4G LTE connectivity (no smartphone required), Sony IMX681 12MP dual-cam system, Qualcomm Snapdragon AR1 Gen 1 processor, MicroLED display, and standalone AI assistant. Note: The X3 Pro uses 4G LTE — not 5G-A. The industry roadmap targets 5G-A-native glasses by 2027 (Ray Neo X5 generation), at which point uplink live-streaming performance will step-change from 30–80 Mbps (4G) to 200+ Mbps (5G-A multi-CC).

The XR market in the GCC is expected to reach USD 2.3 billion by 2028, with Kuwait's entertainment, retail, and education sectors identified as primary deployment environments. Kuwait's indoor 5G-A program is a direct enabler of XR applications in malls, museums, and event venues.

2.3 AI Vehicles (Connected & Autonomous)

Vehicle-to-Everything (V2X) connectivity on 5G-A enables the real-time data exchange that underpins safe autonomous and semi-autonomous driving. Kuwait's Vision 2035 urban mobility ambitions intersect directly with 5G-A network requirements for vehicular communications:

- C-V2X (Cellular V2X, 3GPP R16/18): Direct vehicle-to-vehicle and vehicle-to-infrastructure communication at <1ms latency
- 100+ sensors per vehicle: LiDAR, radar, cameras generating 4 TB/day requiring selective edge offload
- HD map updates: Real-time high-definition mapping via 5G-A at 1–10 Mbps continuous uplink
- Robo-Taxi requires higher uplink network capability: normal driving require 5Mbps uplink for 2 front cameras, at least 20Mbps for remote takeover, 50Mpbs for upload 90s surveillance video in 3 min of accident.
- Platooning & cooperative driving: Ultra-reliable low latency communication (URLLC) for convoy formation

Kuwait's planned smart city corridors and the Future City development areas are natural deployment zones for automotive 5G-A infrastructure.

2.4 AI Robots

The convergence of humanoid robotics, industrial automation, and 5G-A connectivity is accelerating rapidly. A landmark moment occurred in February 2025, when the Chinese Spring Festival Gala (CCTV, ~1 billion viewers) featured a synchronized performance of 200+ humanoid robots from multiple Chinese manufacturers — simultaneously dancing, moving in precise formation, and interacting with performers. This was not a demo: it was a live, networked deployment that demonstrated China's industrial-scale humanoid robot production capability.

> **2025 Spring Festival Gala — The Robot Turning Point**
>
> AgiBot deployed 200+ of its A2 humanoid robots in a fully synchronized live performance for an audience of ~1 billion. Unitree Robotics and UBTECH Robotics also featured units. The performance required continuous 5G-A low-latency coordination across all 200+ robots simultaneously — real-time command and telemetry synchronization that is technically impossible on 4G or Wi-Fi at that scale. This event signals that humanoid robot mass production has arrived.

AI robots connected via 5G-A enable a new class of real-world applications that extend well beyond industrial automation:

- Industrial automation: Manufacturing quality control at microsecond decision speeds via edge AI — 5G-A URLLC replaces wired control links
- Logistics robotics: Real-time warehouse coordination across dense device populations — 5G-A multi-robot mesh coordination
- Humanoid robots: ~20 joints × 200 Hz sensing = ~4 KB/s continuous telemetry per robot; 200 robots = 800 KB/s uplink with <1ms sync
- Healthcare assistance: Surgical assistance and patient care robotics requiring URLLC-grade 1ms reliability
- Entertainment & public services: AgiBot A2, Unitree H1/G1, UBTECH Walker X — commercial units available now for deployment in Kuwait's malls, airports, and cultural venues
- 5G-A requirement: Synchronized multi-robot control at >100 units requires 5G-A URLLC + network slicing — 4G networks cannot guarantee the <1ms latency and isolation needed

Device Category	Current Units in GCC	2028 Projection
AI Smartphones	~12M	~25M
AI Tablets & Wearables	~3M	~8M
XR Headsets & AI Glasses	~200K	~2M
Connected AI Vehicles	~500K	~2.5M
Industrial AI Robots	~50K	~400K

2.5 Network Implications for 5G-A

The AI device ecosystem drives fundamentally different network traffic patterns than previous device generations. CITRA's network planning framework must account for:

Traffic Pattern Shift

Traditional 5G traffic: bursty, asymmetric (downlink-heavy). AI device traffic: sustained, bidirectional, latency-sensitive, large uplink speed. XR traffic: symmetric high-bandwidth. Vehicle/Robot traffic: ultra-low latency, high reliability. This shift requires 5G-A's multi-CC architecture and AI-native QoS frameworks.

CH 3 **Global Benchmarking**
Kuwait vs World Leaders

Global Benchmarking: Kuwait as a World Leader

Kuwait's 5G performance metrics rank among the world's best — yet the path to declared leadership requires understanding the specific advantages and strategies of current global leaders. This chapter benchmarks Kuwait against leading nations across key performance indicators.

3.1 Ookla Global Speedtest Rankings (2026)

Country	Ookla Rank	Avg Speed (Mbps)	Indoor 5G-A	Key Advantage
UAE	#1	~644+	Comprehensive	Indoor 5G-A at airports, malls, offices
Qatar	#2	~576	Major venues	High 5G-A penetration, dense small cells
Kuwait	#3 → Target #1	~372 → 644+	Ongoing	Highest 5G adoption globally;
Saudi Arabia	#4	~226+	Major cities	Large spectrum allocation, rapid rollout
South Korea	#5	~265	Nationwide	5G SA, network slicing maturity
China	Top 10	~420	Extensive	World's largest 5G deployment, 500K+ sites

3.2 Global 5G Benchmarking

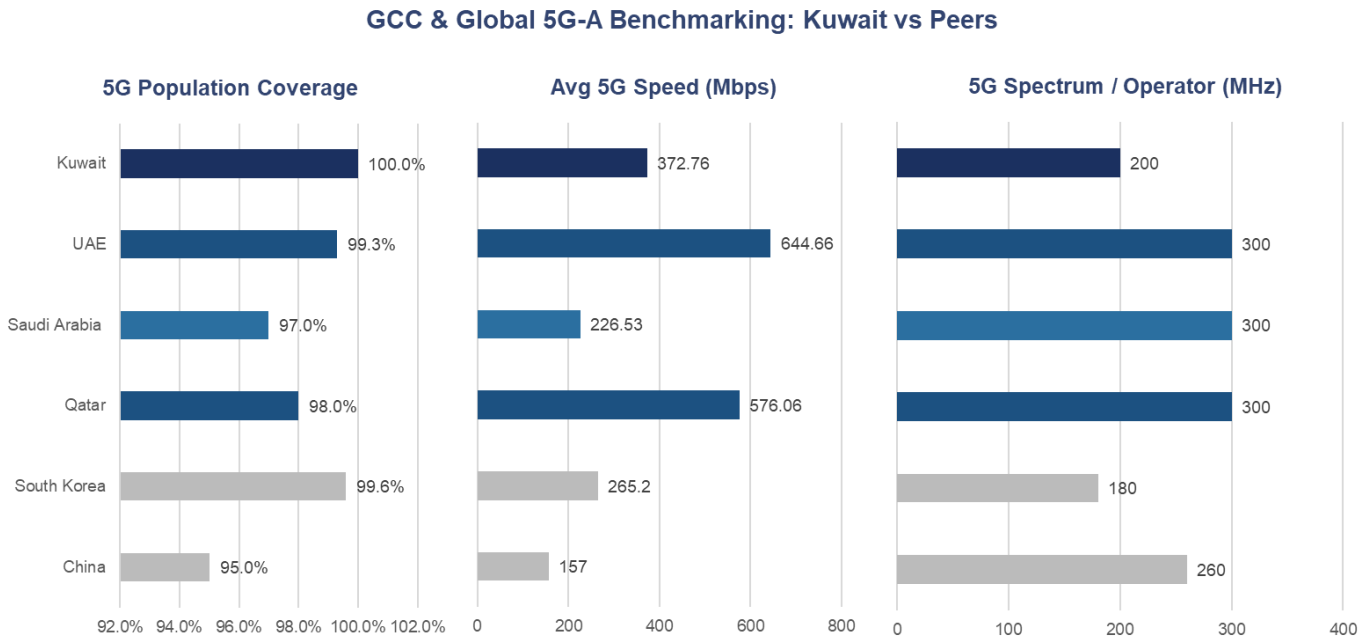

Figure 4 | GCC & Global 5G-A Benchmarking: Kuwait vs Peers

3.3 Global 5G-A Coverage Leaders

Country	5G Coverage	5G-A Sites	SA/NSA	Spectrum/Operator
Kuwait	100%	~3,000 5G-A	NSA/SA	190–200 MHz (2CC)
UAE	99%	5,000+	SA	300 MHz
South Korea	95%	130,000+	SA	100 MHz
China	92%	3.5M+	SA	260~ MHz
Finland	99%	8,000+	SA	200 MHz

3.4 Key Lessons from Global Peer Leaders

Lesson 1: UAE — Indoor and spectrum policy with supervision

UAE's #1 Ookla position is driven by allocating 300 MHz 5G spectrum bandwidth per operator. In addition to systematic indoor 5G-A deployment using Digital Indoor Solution (DIS) at major commercial venues, achieving 5.1 Gbps peak indoor speeds. These annual network improvements are driven by UAE TDRA supervision, which is great and prime opportunity for CITRA Kuwait to drive enhancements and experiences.

Lesson 2: South Korea — Ecosystem Breadth

South Korea achieved rapid 5G-A adoption through a combination of device subsidisation, 5G-A-exclusive content (streaming, gaming), and mandatory 5G support for enterprise contracts. Kuwait's activation program should draw on this model.

Lesson 3: China — Integration at Scale

China's 5G-A ecosystem success stems from integration across the full value chain: manufacturing, application development (Alibaba, Tencent), and government mandates for 5G-A in industrial zones. Kuwait's free trade zones and logistics hubs offer parallel opportunities.

Kuwait 5G-A: Current State Assessment

Kuwait's mobile telecommunications sector has achieved remarkable performance metrics that position it as a global benchmark. This chapter provides a rigorous current state assessment, including the critical indoor coverage gap that defines Kuwait's primary strategic challenge.

4.1 Key Performance Indicators — 2026

#1	100%	4.12M	68%+	1.2M+	~3,000
Global 5G Rank	Population 5G Coverage	Subscribers 5G Users	% of Total 5G Traffic	Activated 5G-A Users	All Outdoor 5G-A Sites

4.2 Operator 5G-A Spectrum Configuration

Operator	Spectrum Bands	Total MHz	Carrier Config	Status
Zain Kuwait	N78 (C-band) + 2.6 GHz	200 MHz	2CC	Commercial ✓
Ooredoo Kuwait	N78 (C-band) + 2.3 GHz	200 MHz	2CC	Commercial ✓
STC Kuwait	N78 (C-band) + 2.6 GHz	~190 MHz	2CC	Commercial ✓

Zain Kuwait World-Record Trial

Zain Kuwait demonstrated 31 Gbps peak throughput using four-band carrier aggregation: Upper 6 GHz + mmWave (28 GHz) + C-band (3.5 GHz) + 2.6 GHz. This establishes the technical proof-of-concept for Kuwait's 10 Gbps commercial target.

4.3 5G-A Commercial Differentiation

Kuwait's operators have introduced differentiated 5G-A pricing and service tiers — a significant market maturity indicator. Three observable commercial signals confirm 5G-A's commercial traction:

- Dedicated 5G-A tariff plans at premium price points vs standard 5G plans
- ARPU uplift of 15–25% observed among 5G-A subscribers vs 5G-only users
- Enterprise 5G-A SLAs introduced with guaranteed minimum throughput commitments

4.4 The Indoor Coverage Analysis

Kuwait's telecommunications landscape is characterized by a robust and mature indoor infrastructure, with operators having successfully deployed comprehensive coverage across the nation's most vital landmarks. High-traffic environments, including premier shopping malls, hospitals, international airport terminals, and key government facilities, are currently served by a seamless multi-generational stack of 2G, 4G, and 5G technologies. Building upon this sophisticated groundwork, the strategic transition to 5G-A indoor deployment represents the next natural evolution. By integrating 5G-A into these established locations, Kuwait is positioned to further enhance network performance and maintain its trajectory toward global leadership in connectivity.

Indicator	Global Benchmark	Kuwait Status	Implication
Indoor traffic share	70–80%	Similar	Majority of demand is indoor
Enterprise indoor demand	60–70%	Similar	High-value segments underserved
2.3/2.6 GHz Building Entry Loss	8–18 dB	8–18 dB	Better passive indoor reach; but insufficient for Ookla benchmarks or deep indoor
C-band Building Entry Loss	15–25 dB	15–25 dB	5G-A primary speed carrier critically attenuated indoors — full 2CC collapses at 30–50m
5G-A Indoor Sites	UAE: 5,000+ venues	Ongoing	Deployment in key areas such as Kuwait International airport Terminal-2, and others.

4.5 F5G-A Fixed Network Status

Alongside mobile 5G-A, Kuwait's fiber infrastructure is planned to scale significantly. The Beyon PPP project (February 2026) represents the most ambitious fixed broadband commitment in Kuwait's history, directly complementing the 5G-A mobile strategy. Key fixed network milestones include FTTH coverage across Kuwait City, enterprise fiber at all major commercial zones, and carrier-grade fiber backhaul supporting 5G-A small cell fronthaul at sub-microsecond latency. The fixed–mobile

convergence this creates is unique globally: by 2028, Kuwait will be the only nation where both residential fixed (10 Gbps GPON) and mobile (10 Gbps 5G-A Phase 3) deliver 10 Gbps simultaneously.

Fixed Network Foundation

Kuwait's FTTH penetration exceeds 90% in Kuwait City, with multi-gigabit symmetric speeds supporting enterprise 5G-A backhaul at <1 ms latency. This fixed–mobile convergence advantage is a critical enabler of 5G-A's 10 Gbps ambition — the backbone infrastructure must match the air interface.

CH 4B Indoor 5G-A
The Missing Layer

Indoor 5G-A Layer

Indoor connectivity is the single most impactful lever available to Kuwait in its pursuit of the Ookla #1 global ranking. This chapter provides a comprehensive analysis of indoor 5G-A technology options, the national deployment program framework, and the direct connection between indoor coverage and Kuwait's speed ranking ambitions.

The Physics of Indoor 5G-A: Why Bands Matter

70–80% of mobile data traffic is generated indoors. Kuwait's 5G-A operators deploy two bands: 2.3/2.6 GHz (8–18 dB building entry loss) and C-band 3.5 GHz (15–25 dB). While 2.3/2.6 GHz provides better passive penetration, C-band — the carrier that delivers the speed advantage of 5G-A carrier aggregation — is structurally compromised through concrete. Full 5G-A multi-carrier performance requires dedicated indoor infrastructure. No outdoor densification can substitute for the physics of RF propagation through buildings.

4B.1 Why Indoor 5G-A is Essential

The traffic economics are straightforward: operators and regulators maximize network return on investment by ensuring coverage where users actually consume data. Four data points define the imperative:

- 70–80% of all mobile data: consumed indoors (3GPP TR 36.814)
- 60–70% of enterprise revenue: generated in indoor environments (offices, factories, warehouses)
- 8–25 dB Band-Dependent Building Entry Loss: 2.3/2.6 GHz bands experience 8–15 dB loss; C-band (3.5 GHz) 15–25 dB. Both bands degrade indoors, but C-band — the primary 5G-A speed carrier — is structurally compromised through concrete buildings
- USD 12.89B indoor 5G market (2024): growing at 22.9% CAGR — the fastest-growing infrastructure segment globally

4B.1A The Multi-Band Indoor Reality: 2.3/2.6 GHz vs C-Band

A key misconception in indoor coverage planning is treating all 5G-A spectrum identically. Kuwait's operators currently deploy two-carrier aggregation (2CC): C-band (~3.5 GHz) plus 2.3/2.6 GHz. These bands behave fundamentally differently indoors — a distinction that directly shapes CITRA's indoor 5G-A deployment strategy.

Frequency-Dependent Building Entry Loss (BEL)

Building Entry Loss (BEL) is the signal attenuation a radio wave suffers when penetrating a building exterior. Per 3GPP TR 38.901 and ITU-R P.1238 standardized models, BEL increases with frequency — meaning higher frequencies experience greater indoor signal loss than lower frequencies.

Band	Frequency	Typical BEL (Concrete)	Indoor Speed (Passive)	Carrier Role in Kuwait 2CC
2.3 GHz (n40)	2.3 GHz	8–15 dB	300–800 Mbps (shallow)	Secondary CC — better indoor reach; used by Ooredoo and STC
2.6 GHz (n41/n7)	2.6 GHz	10–18 dB	200–600 Mbps (shallow)	Secondary CC — China's primary 5G indoor band; strong passive penetration
C-band (n77/n78)	3.5 GHz	15–25 dB	50–300 Mbps (perimeter only)	Primary CC — delivers 5G-A speed advantage; severely attenuated through concrete
mmWave (n258)	26/28 GHz	35–50+ dB	<5 Mbps or no coverage	Future Phase 4 band — requires dedicated indoor small cells; cannot penetrate buildings

The 3.6 dB Penetration Advantage of 2.3/2.6 GHz

Research shows 2.3–2.6 GHz bands provide ~3.6 dB better building penetration than 3.5 GHz C-band (3GPP TR 38.901). This translates to ~2.3× more received signal power indoors. In practice, shallow indoor speeds on 2.3/2.6 GHz can reach 300–800 Mbps — significantly better than 50–300 Mbps for C-band at equivalent indoor distances. China Mobile's n41 (2.6 GHz) deployment achieves consistent indoor 5G coverage in concrete high-rises where C-band alone would fail.

Why 2.3/2.6 GHz Alone Is Not Sufficient

Despite the penetration advantage, 2.3/2.6 GHz passive indoor coverage has three critical limitations that make dedicated indoor infrastructure still mandatory for Kuwait's indoor 5G-A program:

Limitation	Technical Explanation	Kuwait Implication
Multi-CC Aggregation Fails Indoors	At 30–50m indoor depth, C-band component drops link; 5G-A 2CC becomes single-band 2.3/2.6 GHz only. Speed collapses from 3 Gbps to 300–600 Mbps — losing the entire 5G-A advantage.	Dedicated indoor systems restore both carriers indoors, enabling true 5G-A multi-CC with 3 Gbps+ indoor performance.
Deep Indoor / Basement Zero Coverage	Even 2.3 GHz cannot reach basement levels, underground malls, parking structures, or deep interior zones of large floor plates (>50m from perimeter). Floor penetration adds 14+ dB per floor at 3.5 GHz (ITU-R P.1238).	Kuwait's major commercial complexes (The Avenues 380,000 sqm, 360 Mall, underground parking) require dedicated active systems for basement and deep-floor coverage.

Energy-Efficient Buildings Block All Bands	Modern buildings with low-E glass, dense concrete, and steel frames attenuate even 2.3 GHz by 25+ dB — equivalent to C-band in traditional concrete. Kuwait's newer towers increasingly use these materials.	New construction mandates (§4B.3) must require infrastructure conduit regardless of band, as all passive signals degrade in modern energy-efficient structures.
Ookla Benchmark Threshold	UAE's TDRA indoor benchmark target is 500+ Mbps at all test points. Passive 2.3/2.6 GHz penetration can only reliably deliver 200–500 Mbps at shallow indoor locations — insufficient for consistent benchmark compliance at all test points throughout large venues.	Kuwait's indoor 5G-A program must target 500+ Mbps throughout all Ookla benchmark venues — achievable only with dedicated indoor small cells or DAS, not passive penetration alone.

CITRA Policy Implication: Passive Coverage ≠ Indoor 5G-A

No international regulator — China MIIT, UAE TDRA, Saudi MCIT, or Hong Kong OFCA — accepts passive 2.3/2.6 GHz outdoor signal penetration as compliance with mandatory indoor 5G coverage requirements. The 2.3/2.6 GHz advantage improves baseline indoor experience for users near windows and perimeters, but CITRA's IBS mandate and Ookla #1 strategy require active dedicated indoor systems capable of delivering guaranteed 500+ Mbps throughout all priority venue categories.

4B.2 Global Indoor Coverage Policy Benchmarks

CITRA is not developing its indoor 5G-A framework in isolation. Four international regulatory authorities have already defined indoor coverage mandates that Kuwait can directly reference and adapt for its proposed IBS (In-Building Solution) criteria. These benchmarks — from China, Hong Kong, Saudi Arabia, and the UAE — represent the current state of best practice in mandatory indoor 5G-A regulation.

Regulator	Program	Key Metric	Regulatory Approach & Key Outcomes
China MIIT	"Signal Upgrade" Special Action	>80,000 venues (2024) >120,000 venues (2025)	National mandatory program covering airports, malls, stadiums and universities. Performance floors: Avg DL >220 Mbps, Avg UL >45 Mbps. Largest indoor 5G deployment in the world.
Hong Kong OFCA	5G Indoor Labelling Scheme	Mandatory operator access to properties	Regulations formulated by the telecommunications authority requiring building owners to grant operator access. Mandatory building entry enables systematic indoor 5G deployment across all 6+ floor properties in the territory.
Saudi Arabia MCIT	5G Small Cells White Paper	Mandatory indoor coverage at key venues	Comprehensive regulatory framework mandating indoor 5G/5G-A coverage at key locations with defined speed, latency and performance thresholds. Public consultation document that Kuwait can use as a direct template for its own mandatory IBS framework.

UAE TDRA	Indoor Benchmark Testing Program	50 key venues — Ookla #1	TDRA drives UAE network ranking #1 globally (Ookla). Mandatory benchmark testing across 50 priority locations including hotels, malls, landmarks and government buildings. Direct causal link between indoor 5G-A benchmarking and global speed ranking leadership.

> **The Lesson for Kuwait**
>
> Benchmark countries explicitly mandates indoor benchmark testing at key venues and buildings. UAE for example directly credits this program with achieving the Ookla #1 global ranking. Kuwait must replicate these regulatory mechanisms: mandatory indoor 5G-A at priority venues, with measurable performance thresholds and public reporting — not voluntary operator commitments.

4B.3 Proposed IBS Criteria for Kuwait

Based on the international benchmarks above, CITRA is conducting studies to establish Indoor Building Solution (IBS) criteria for Kuwait. The proposed framework distinguishes between general mandatory criteria — applicable to any building meeting physical thresholds — and 10 priority public scenario categories requiring immediate indoor 5G-A deployment.

General IBS Trigger Criteria

Any building or development meeting one or more of the following physical or occupancy thresholds should be subject to mandatory indoor 5G-A infrastructure obligations:

Criterion	Threshold	Rationale
Building Height	6 or more floors	C-band outdoor signals cannot serve upper floors through building walls — Indoor-by-default above 6 floors
Occupancy / Footfall	1,000+ simultaneous users expected	High-density venues create macro network congestion — dedicated indoor capacity is essential
Floor Area	3,000+ square metres (single floor or aggregate)	Large floor plates have no outdoor signal path — dedicated indoor system required for full coverage
Basement Depth	2 or more basement floors	Subterranean environments receive zero outdoor signal — mandatory dedicated indoor system
Public Access Requirement	Mandatory building access for operators	Building owners required by regulation to grant access to all licensed MNOs or an approved NHO. Public and government buildings to open free access.

Technology Standard	5G (minimum) or 5G-A where technically feasible	New builds and major refurbishments must install 5G-capable infrastructure

10 Key Public Scenarios — Priority Mandatory Venues

Beyond the general criteria, CITRA should mandate indoor 5G-A deployment at all venues in the following 10 public scenario categories — regardless of whether they meet the physical thresholds above — given their strategic importance to Kuwait's Ookla benchmark performance, public safety, and economic activity:

#	Venue Category	Kuwait Examples	Regulatory Requirement
01	Airport	Kuwait International Airport (Terminal 1 & 2, New Terminal)	Mandatory indoor 5G-A in all public areas, gates, lounges and baggage halls. Performance floor: >500 Mbps average
02	Landmark / Heritage Sites	Kuwait Towers, Liberation Tower, Grand Mosque	Indoor/indoor-proximate 5G-A for tourist zones and visitor centers with mandatory signage
03	Shopping Mall	The Avenues, 360 Mall, Marina Mall, Al-Kout	Full-building indoor 5G-A — highest Ookla benchmark impact; mandatory for malls >30,000 sqm
04	Five-Star Hotels	Four Seasons, JW Marriott, Jumeirah Messilah, Kempinski	Guest rooms and all public areas; meets international traveller quality expectations
05	Government Buildings	National Assembly, Ministries, Amiri Diwan complex	Secure indoor 5G-A for citizen-facing service areas; supports digital government transformation agenda
06	Scenic / Tourist Spots (3A+)	Al-Shaheed Park, Entertainment City, Salmiya Corniche	Outdoor-heavy but enclosed structures must have indoor 5G-A; critical for social media & tourism apps
07	Major Hospital (MOH)	Mubarak Al-Kabeer, Al-Sabah, Jaber Al-Ahmad Medical City	Full in-building 5G-A for telemedicine, connected ambulance handoff and patient monitoring applications
08	University Campus	Kuwait University, Gulf University for Science & Technology, AUK	All major lecture halls, libraries and student hubs; enables smart campus and 5G-A research pilots
09	Museum / Cultural Venue	Sheikh Abdullah Al-Salem Cultural Center, National Museum	AR/XR experience enablement; establishes Kuwait as a smart tourism destination
10	VIP / Executive Venues	Private clubs, executive business districts, Marina zone	High-value user segment requiring guaranteed 5G-A quality; critical for high ARPU data consumption

4B.4 Indoor 5G-A Technology Options

For Kuwait's 5G-A ambitions, indoor connectivity is no longer a coverage enhancement but a fundamental network layer. With 70–80% of mobile data traffic generated indoors and the performance of mid-band 5G spectrum (2.3/2.6 GHz and 3.5 GHz) significantly impacted by building penetration loss, achieving consistent multi-Gbps user experience requires dedicated indoor infrastructure rather than reliance on outdoor macro densification alone. The industry has consequently evolved from traditional passive Distributed Antenna Systems (DAS) toward digital and intelligent indoor architectures that integrate radio access, fiber transport, and centralized management. Leading vendors have converged on this approach through solutions such as Huawei LampSite, Ericsson Radio Dot System, and Nokia Kolibri Indoor Small Cells, all of which provide multi-band, multi-operator support, carrier aggregation, MIMO capabilities, and seamless integration with the macro network to deliver true 5G-A performance indoors.

The optimal indoor technology choice depends on venue characteristics, capacity requirements, and future digitalization objectives. Large and high-density environments such as airports, stadiums, hospitals, convention centers, and transportation hubs are best served by active digital indoor systems (DIS) or advanced Active-DAS architectures that offer centralized coordination, intelligent resource allocation, and support for 5G-A features including multi-carrier aggregation and network slicing. Medium-sized enterprises, shopping malls, hotels, and office buildings can be efficiently addressed using fiber-based small-cell solutions, which provide scalable capacity, simplified deployment, and lower total cost of ownership. As indoor networks evolve beyond connectivity to support positioning, IoT, automation, and AI-driven services, digital indoor systems will increasingly become strategic infrastructure assets that enable both superior user experience and new enterprise use cases, making indoor 5G-A deployment a critical pillar of Kuwait's digital transformation and global broadband competitiveness.

4B.5 Neutral Host Model & CITRA Framework

International best practice for indoor 5G-A deployment increasingly uses a Neutral Host model — a single infrastructure layer serving all operators simultaneously, eliminating duplicated in-building equipment. CITRA's regulatory framework should mandate:

- Building owner/developer obligation: New construction above 5,000 sqm to include neutral host infrastructure conduit (passive or active) supporting all licensed frequency bands including 2.3/2.6 GHz and C-band simultaneously
- Neutral Host Operator (NHO) license: CITRA to create a new license class enabling third-party indoor infrastructure operators
- Multi-operator connectivity: NHO infrastructure must be operator-agnostic, serving all licensed MNOs
- Public buildings: Government buildings, airports, hospitals to provide carrier access for indoor 5G-A at cost-regulated rates

4B.6 National Indoor 5G-A Priority Program

Priority Tier	Venue Type	Timeline	Expected Coverage Impact
Tier 1	International airports, major hospitals, Kuwait City core	2025–2026	High-speed 5G-A for highest-traffic, highest-visibility venues
Tier 2	Major shopping malls (360 Mall, The Avenues, Marina Mall)	2025–2026	Consumer 5G-A experience, direct Ookla score impact
Tier 3	Enterprise campuses, industrial zones, Jaber Al-Ahmad City	2026–2027	Enterprise 5G-A revenue, private network foundation
Tier 4	Residential towers >30 floors, educational institutions	2027–2028	Nationwide indoor coverage reaching 80% target

4B.7 Indoor Coverage and the Ookla #1 Strategy

The mathematical case for indoor coverage as the path to Ookla #1 is clear. The Ookla Speedtest methodology measures the average download speed across all user tests, including those conducted indoors. UAE's ~644 Mbps advantage over Kuwait's ~372 Mbps (+168 Mbps gap) is driven primarily by indoor test performance at high-density venues.

Scenario	Indoor Speed	Avg Speed Impact	Ookla Rank Implication
Current (zero indoor 5G-A)	30–80 Mbps	~372 Mbps avg	#3 globally
Tier 1 deployed (airports, malls)	800–2000 Mbps	~430 Mbps est.	#2 possible
Tier 1+2 deployed (full commercial)	1–3 Gbps	~490 Mbps est.	#1 achievable
Full program (+ 3.8 GHz spectrum)	3–5 Gbps	600+ Mbps est.	#1 sustained, leadership margin
Phase 4 mmWave indoor (2029+)	20+ Gbps (hotspots)	2+ Gbps est.	Unchallenged global leadership — world first 20 Gbps indoor

CH 5 Sector Transformation
5G-A & AI Across Kuwait's Economy

Sector Transformation: 5G-A & AI Across Kuwait's Economy

5G-A and AI are simultaneously a general-purpose technology platform and a sector-specific enabler. Kuwait's diversified economy — spanning oil & gas, financial services, logistics, healthcare, and an ambitious Vision 2035 diversification agenda — presents an exceptional opportunity for 5G-A-driven productivity gains. The ten sectors profiled below map directly to Vision 2035's strategic pillars: healthcare, education, smart infrastructure, living environment, global positioning, and economic diversification. Each use case is both a commercial opportunity and a national development obligation.

5.1 Healthcare: Precision & Remote Medicine

Vision 2035 Healthcare Pillar: $10B annual budget, $200M digital health investment, AI diagnostics at Jaber Hospital, telemedicine expansion — all require 5G-A as their connectivity layer. Indoor 5G-A coverage in every hospital and clinic is a prerequisite, not an optional enhancement, for Health Vision 2035.

- AI-assisted diagnostics: Real-time medical imaging transmission at 4K/8K resolution via 5G-A (200 Mbps uplink required)
- Remote robotic surgery: URLLC 5G-A enabling sub-1ms latency for surgical robot control
- Hospital campus private networks: 5G-A private networks providing dedicated coverage for IoT devices, wearables, and medical equipment
- AI triage systems: Ambulance-to-hospital pre-triage via 5G-A-connected vital sign monitoring

5.2 Education: Immersive Learning

Vision 2035 Human Capital Pillar: Complete education system reform toward a knowledge-based economy requires immersive digital learning tools. 5G-A enables the AR/VR classrooms, AI-personalized curricula, and equal-access remote education that transform Vision 2035's Human Capital aspiration into operational reality.

- XR-based education: VR/AR classrooms requiring 5G-A's dedicated XR QoS (100+ Mbps, <5ms latency)
- AI tutoring systems: On-device and cloud AI tutors enabled by 5G-A-connected AI smartphones and tablets
- Campus 5G-A: Private 5G-A networks for universities enabling research applications, IoT labs, and digital libraries

5.3 Oil & Gas: Intelligent Operations

- Industrial IoT on 5G-A: Wireless sensor grids replacing cable infrastructure, 100,000+ devices per site
- AI predictive maintenance: Vibration, thermal, and acoustic sensor data processed at edge for real-time equipment health monitoring
- Remote operations: 5G-A-connected camera systems enabling unmanned facility management
- Digital twin integration: Real-time plant digital twins requiring continuous high-bandwidth data feeds

5.4 Ports & Logistics

- Automated port operations: 5G-A connecting cranes, AGVs (Automated Guided Vehicles), and port management systems
- Ship-to-shore connectivity: mmWave 5G-A for high-speed vessel connectivity at Shuwaikh and Mina Al-Ahmadi
- Real-time cargo tracking: Ambient IoT tags on containers, tracked via 5G-A network
- AI customs: 5G-A-connected AI inspection systems accelerating customs clearance

5.5 Smart Cities & Government Services

Vision 2035 Infrastructure Pillar: The $27.6B South Saad Al-Abdullah smart city (designed for 400,000 residents) and Kuwait's $193B project pipeline explicitly require 5G-A-grade IoT connectivity. The Living Environment pillar adds air quality monitoring, smart waste, and connected buildings as mandatory digital services — all 5G-A-dependent.

- Traffic intelligence: AI-analyzed camera feeds (200+ cameras/km in smart corridors) via 5G-A backhaul
- Smart street lighting: 5G-A-connected municipal IoT reducing energy consumption 30–40%
- Emergency response: First responder 5G-A connectivity for real-time command and URLLC communications
- Digital government services: 5G-A-enabled kiosk networks and citizen service access points

5.6 FinTech & Digital Finance

Vision 2035 Economy Pillar: ICT market growth from $22.5B (2023) to $39.8B (2029), non-oil GDP expansion, and 69% private sector employment growth all depend on a digital financial services ecosystem built on 5G-A connectivity and AI analytics.

- Real-time payment infrastructure: 5G-A-enabled POS systems and instant settlement networks
- AI fraud detection: Edge AI processing at <1ms for instant transaction analysis
- Biometric banking: 5G-A-connected facial recognition and liveness detection for secure authentication
- Digital currency infrastructure: CBDC (Central Bank Digital Currency) infrastructure leveraging 5G-A's high-reliability connectivity

5.7 Retail & XR Entertainment

- AR shopping: 5G-A-enabled AR try-before-you-buy in malls — direct beneficiary of indoor 5G-A deployment
- Immersive entertainment: VR gaming and location-based XR experiences requiring 200 Mbps per user
- AI personalisation: Real-time AI recommendation engines via edge computing
- Virtual events and concerts: XR streaming from Kuwait venues to global audiences via 5G-A uplink

5.8 Agriculture & Water Management

- Smart irrigation: 5G-A-connected soil sensors enabling precision water management in Kuwait's agriculture zones
- Drone monitoring: Autonomous agricultural drones using 5G-A control links for real-time crop analysis
- AI weather analytics: Hyperlocal weather data from 5G-A sensor networks improving harvest planning

5.9 Public Safety & Homeland Security

- Mission-critical communications: 5G-A MCPTT (Mission Critical Push to Talk) replacing legacy TETRA systems
- Border surveillance: AI-connected camera networks with real-time analytics via 5G-A
- Disaster response: Deployable 5G-A cells for rapid network restoration in emergency scenarios
- Biometric identity: 5G-A-connected facial recognition at high-traffic border crossings

5.10 Connected Vehicles & Transport

- Kuwait City traffic management: C-V2X 5G-A infrastructure for intersection collision avoidance
- Autonomous bus lanes: Pilot programs for self-driving public transport on dedicated 5G-A-equipped corridors
- Fleet management: Real-time vehicle telemetry for logistics and municipal fleets via 5G-A IoT
- EV charging network: 5G-A-connected smart charging infrastructure with dynamic load balancing

CH 6 **Network AI & Intelligent Automation**
AI-Native Telecommunications

Network Intelligence: Autonomous Network, Edge Computing & Green 5G-A

The most transformative aspect of 5G-A is not its speed but its intelligence. AI for Network capabilities (Autonomous Network), Multi-Access Edge Computing (MEC), and advanced energy management are converging to create a self-optimising network infrastructure.

6.1 AI-Native RAN Architecture

3GPP Release 18 introduces the first standardized AI/ML framework for RAN operations. Kuwait's operators can leverage this to achieve significant performance improvements without additional spectrum expenditure:

- AI Beam Management: Predictive beam steering using user trajectory models — 15–20% throughput gain in pedestrian-dense areas
- AI Channel Estimation: ML-based interference prediction improving edge-of-cell performance by 25–35%
- AI-driven Carrier Aggregation scheduling: Intelligent band selection across 2CC/3CC configurations based on real-time conditions
- Predictive Handover: AI anticipates cell transitions 100–200ms in advance, eliminating handover interruptions

6.2 Network Autonomy Levels (TMForum)

Level	Description	Kuwait Target	Key Capability
L1 — Manual	Human-executed all operations	Baseline	Traditional NOC
L2 — Assisted	System provides recommendations, human decides	Current state	AI recommendation engine
L3 — Conditional	Autonomous in defined domains, human oversight	2027 target	Domain-specific self-optimization
L4 — High	Autonomous across network, human monitors exceptions	2030 target	Cross-domain AI orchestration
L5 — Full	Complete end-to-end autonomy, AI manages network lifecycle	2035 (6G era)	Cognitive self-healing network

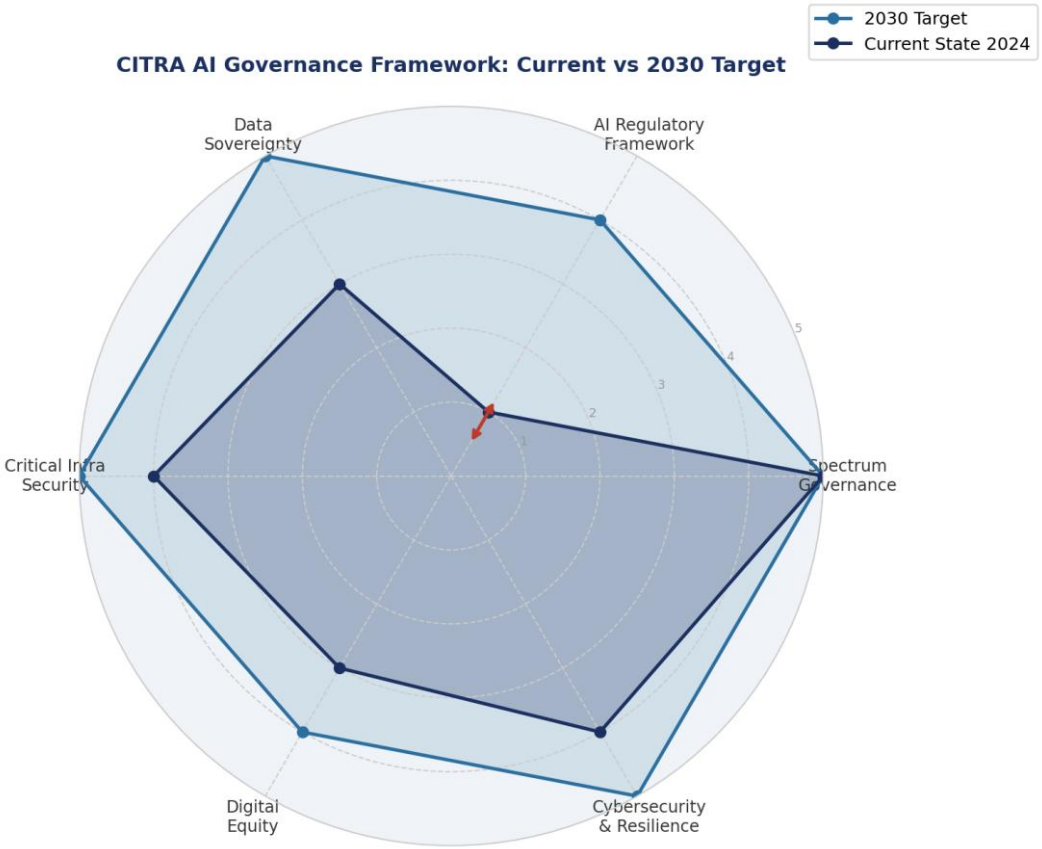

Figure 5 | CITRA AI Governance Framework: Current vs 2030 Target

6.3 Multi-Access Edge Computing (MEC)

MEC places computing resources at the network edge — within operator data centers co-located with base stations — reducing the physical distance between computation and end-device from 500–1,000 km (public cloud) to 5–20 km (edge data centre). The latency improvement is decisive:

Architecture	Typical Latency	Use Cases Enabled
Public Cloud (centralised)	50–150ms	Non-real-time applications, streaming, content delivery
National Edge DC	15–30ms	Video analytics, moderate latency applications
MEC (co-located with RAN)	1–5ms	XR rendering, robotic control, autonomous vehicles, real-time AI inference

6.4 Green 5G-A Program

Kuwait's 5G-A network expansion coincides with national sustainability commitments. CITRA's Green 5G-A Program framework specifies three pillars:

- Advanced Sleep Mode: AI-driven base station sleep during low-traffic periods — 15–30% energy reduction without coverage loss

- Intelligent Cell Management: AI-coordinated cell-load balancing, switching off redundant cells and concentrating traffic on optimal sites
- Renewable Energy Integration: CITRA to mandate minimum 30% renewable energy for new 5G-A site infrastructure by 2028, targeting 60% by 2035

Energy Efficiency Benchmark

Leading 5G-A operators in South Korea and Finland have achieved 35–45% energy reduction per bit transmitted through AI-RAN sleep mode and traffic-aware cell management. Kuwait's Green 5G-A Program targets 25% by 2027 and 40% by 2030.

CH 7 National Roadmap
Vision 2026–2035

National Roadmap to 2035: From 5G-A Leader to 6G Pioneer

Kuwait's National Connectivity Roadmap 2025–2035 is built on four interlocking strategic pillars — spectrum excellence, coverage completeness, AI-native network evolution, and international standard leadership — and is formally aligned with Kuwait Vision 2035 ('New Kuwait'). The connectivity targets in this roadmap are not arbitrary; they are the specific technical parameters required to achieve the Vision's seven pillars: smart infrastructure, diversified digital economy, AI-enabled healthcare, immersive education, sustainable living environment, effective e-government, and global technology leadership. Each aspiration has a defined timeline, measurable KPIs, and clear policy enablers.

7.1 The Four National Aspirations

Aspiration	Description	Target Date	Key Enablers
World's First 10 Gbps Mobile Nation	First country to commercially deliver 10 Gbps peak mobile speed to consumers; Phase 4 mmWave enables 20+ Gbps in hotspots	2028	U6GHz allocation, 5CC aggregation, indoor 5G-A; Phase 4 mmWave (2029–31)
#1 Ookla Global Rank	Achieve 700+ Mbps the highest average download speed globally, surpassing UAE (~644 Mbps)	2026–2027	Indoor 5G-A program, 3.8 GHz release, user activation
80% 5G-A Coverage Indoor + Outdoor	8 in 10 Kuwaitis covered by 5G-A at all times — inside and outside	2028–2029	Indoor program tiers 1–4, operator mandatory obligations
50%+ 5G-A Activated Users	More than 2 million users on 5G-A plans (from 1.2M today)	2027	Device program, subsidy scheme, enterprise activation

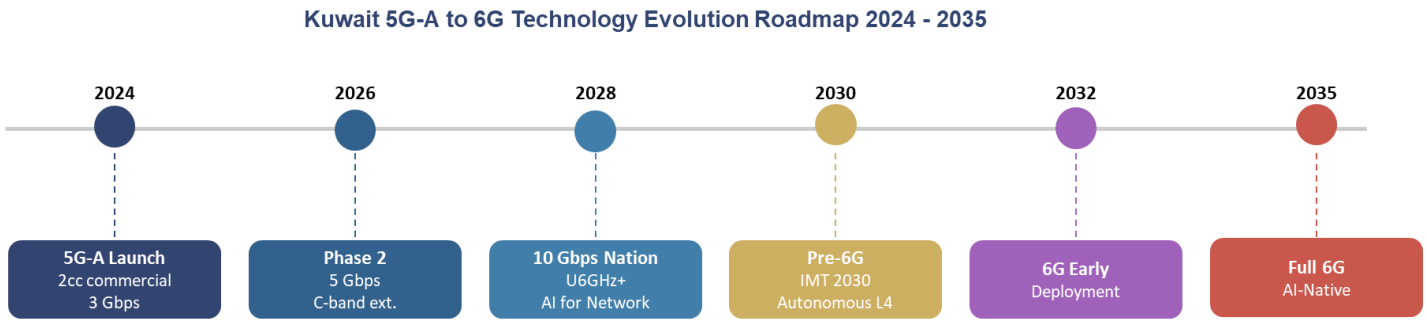

Figure 6 | Kuwait 5G-A to 6G Technology Evolution Roadmap 2024–2035

7.2 Spectrum Release Schedule

Kuwait's 5-phase spectrum roadmap provides a structured path from the current 5G-A commercial baseline through 10 Gbps, mmWave ultra-dense deployment, and ultimately to 6G (IMT-2030). Each phase unlocks a step-change in capability with measurable KPI milestones.

Phase	Spectrum Release	MHz/Operator	Peak Speed	Year
Phase 1: Launch	C-band (3.5GHz) + 2.3/2.6 GHz	190–200 MHz	~3 Gbps	2024–25
Phase 2: Expansion	+ 3.8–4.1 GHz mid-band	~300 MHz	~5 Gbps	2026
Phase 3: 10 Gbps	+ Upper 6 GHz (6425–7125 MHz)	~500 MHz	~10 Gbps	2028 1st 10 Gbps Nation
Phase 4: mmWave	mmWave (24/26/28/39 GHz) — ultra-dense zones	>1,000 MHz	20+ Gbps	2029–2031

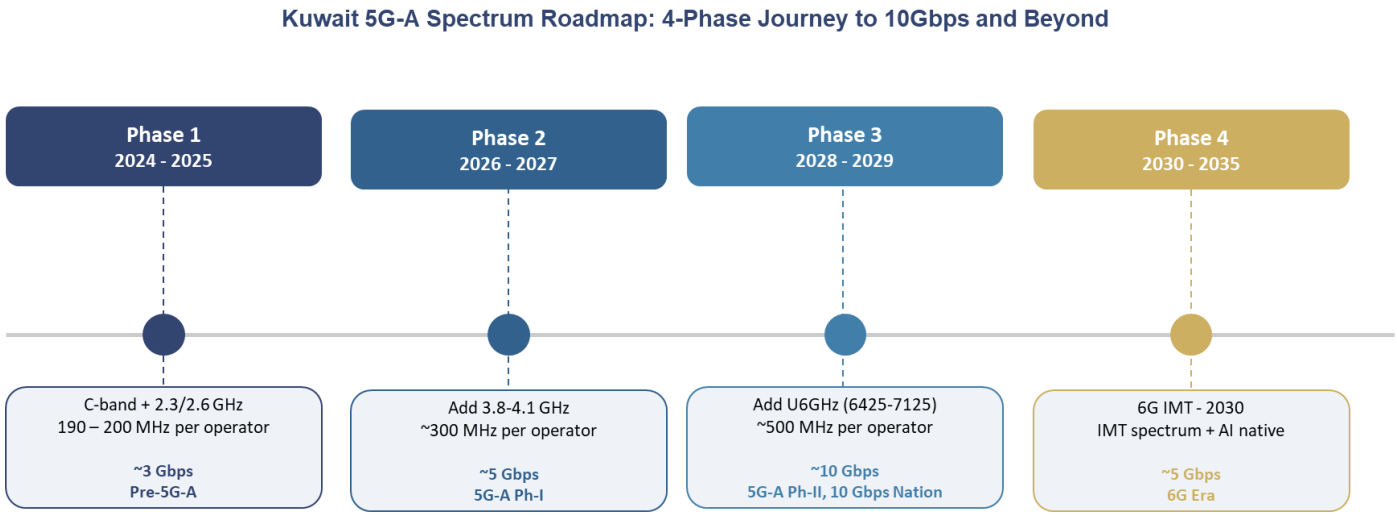

Figure 7 | Kuwait 5G-A Spectrum Roadmap: Journey to 10 Gbps

7.3 KPI Dashboard 2026–2035

KPI	2026 (Now)	2028 Target	2030 Target	2035 Target
5G Coverage	100%	100%	100%	6G ready
5G-A Outdoor Coverage	~40% (2CC)	75% (3CC)	90% (3CC)	95% (3CC)
5G-A Indoor Coverage	0%	60%	80%	90%
Peak Speed	DL:~3 Gbps UL:~300Mbps	DL:~5 Gbps UL:~500Mbps	DL: 10 Gbps UL: 1Gbps	DL: 36Gbps (6G) UL: 3Gbps
Avg Ookla Speed	DL: ~372 Mbps UL: ~34Mbps	DL: 1 Gbps UL: 100Mbps	DL: 2 Gbps+ UL: 200Mbps	DL: 5 Gbps+ UL: 500Mbps+
Avg Latency	40ms	20ms	10ms	8ms
5G-A Activated Users	1.2M (29%)	2.1M (50%+)	3.5M (80%+)	6G transition
5G-A Sites	~3,000 (2CC)	~7,000 (3CC)	~12,000 (3CC)	6G sites
Network AI Level (TMF)	L2	L3	L4	L5 (6G)
Energy Efficiency	Baseline	-25% per bit	-40% per bit	-60%

> **Phase 3 Milestone: World's First 10 Gbps Mobile Nation**
>
> The convergence of Upper 6 GHz spectrum, 5-carrier aggregation, and nationwide indoor 5G-A coverage in 2028 positions Kuwait to become the first country to commercially deliver 10 Gbps peak mobile speeds — fulfilling CITRA's highest national aspiration ahead of the Vision 2035 horizon.

7.4 Policy Framework

Spectrum Policy

- Timely 3.8–4.1 GHz release: complete operator licensing by Q4 2026 for Phase 2 commercial deployment.
- Upper 6 GHz (U6GHz) preparation: International coordination and domestic planning for 2028 release
- mmWave acceleration: Fast-track deployment permits for mmWave 5G-A (26/28 GHz) in enterprise and industrial zones

Indoor 5G-A Program

- Mandatory Indoor Infrastructure Obligation: New commercial buildings >5,000 sqm to include neutral host conduit — mandated in building codes
- Neutral Host Operator License: CITRA to issue NHO license framework by Q4 2026
- Public Building Access: Government mandate for 5G-A access at airports, hospitals, and major government facilities by Q4 2026
- Ookla Monitoring: CITRA to publish regularly Ookla methodology analysis and operator scorecards

User Activation Program

- 5G-A Device Certification: Fast-track CITRA certification for 5G-A devices with R18/R19 support. The 5G-A certified devices are required by operators have ability to show 5G-A logo in 3CC network to demonstrated their service differentiations.
- 5G-A logo and tariff supportive: CITRA set unified 5G-A network standard (e.g., DL 5Gbps speed) and encourage operators release 5G-A logo with new tariff to enhance consumer 5G-A experience
- Consumer incentive scheme: Coordinated operator program for 5G-A device upgrade subsidisation
- Enterprise activation mandate: Government procurement to require 5G-A-capable devices
- Consumer awareness campaign: National "5G-A Kuwait" program with quarterly performance reporting. Several 5G-A leading countries they publish performance results and award the pioneer operator, and CITRA is studying those best practices to enhance Kuwait competitiveness and experience.

6G Readiness Program

- IMT-2030 participation: CITRA will actively contribute to ITU-R IMT-2030 working parties
- 6G research fund: Establishment of Kuwait 6G Innovation Fund in partnership with Kuwait University and operators
- 6G test lab: OpenLab facility for 6G technology trials, to be operational by 2028
- International partnerships: MoUs with South Korea's ETRI, Finland's University of Oulu, and China's CAICT for 6G co-research

CH 8 Governance & Regulatory Framework
CITRA AI Policy Architecture

AI & Data Governance Framework

The AI era introduces a new regulatory frontier for CITRA. While Kuwait has not yet established a dedicated AI regulatory framework, the convergence of AI-native 5G-A networks, AI devices, and AI-powered services creates an urgent imperative for governance. This chapter outlines the five-pillar AI governance architecture that CITRA is studying to establish.

8.1 The AI Governance Imperative

Current Status

CITRA does not currently have a dedicated AI regulatory framework or specific government AI initiatives. As Kuwait's 5G-A networks become AI-native and AI devices proliferate, this gap creates regulatory uncertainty for operators, inhibits enterprise AI adoption, and leaves Kuwaiti data potentially exposed to extraterritorial regulatory frameworks.

8.2 Five-Pillar Governance Architecture

Pillar 1: Spectrum Governance for AI-Native Networks

As 5G-A RAN becomes AI-driven, spectrum allocation decisions must account for AI network behavior. CITRA's spectrum governance framework considers:

- Establish AI-Network performance metrics as part of Quality of Service (QoS) regulatory obligations
- Define AI algorithm transparency requirements for RAN optimization systems
- Create audit rights for AI-driven network decisions affecting service quality

Pillar 2: AI Regulatory Framework

CITRA is conducting studies to establish Kuwait's AI regulatory framework for telecommunications, covering:

- AI system classification: Tiered risk framework (low/medium/high risk) for AI applications on 5G-A networks
- Algorithmic accountability: Obligations for operators to document and explain AI-driven network management decisions
- AI bias prevention: Requirements for AI models used in network resource allocation to be non-discriminatory

- AI safety standards: Technical requirements for AI systems involved in critical infrastructure management

Pillar 3: Data Sovereignty

5G-A network data — including location data, usage patterns, and device identifiers — requires robust sovereign governance:

- Data localisation: Core network data to be stored within Kuwait's borders on sovereign infrastructure
- Roaming data governance: Clear rules for data generated by international visitors on Kuwait's 5G-A networks
- Cross-border data flows: CITRA-issued standard contractual clauses for 5G-A operators sharing data internationally
- Kuwait Data Protection Law alignment: 5G-A operator obligations to be aligned with CITRA's Data Protection Regulation

Pillar 4: Critical Infrastructure & Cybersecurity

- 5G-A Security Baseline: CITRA to adopt NESAS (Network Equipment Security Assurance Scheme) as mandatory certification for all 5G-A network equipment
- Network slice security: Mandatory security isolation standards for 5G-A network slices serving government and critical infrastructure
- Supply chain security: Due diligence requirements for 5G-A infrastructure vendors
- Incident reporting: Mandatory 72-hour reporting for 5G-A network security incidents affecting more than 10,000 users

Pillar 5: Digital Equity & Inclusion

- Universal 5G coverage obligation: extend 5G (not just 4G) coverage obligations to underserved areas
- Affordable 5G-A: Regulatory oversight of 5G-A pricing to ensure access is not limited to premium segments
- Digital literacy program: Government-funded 5G-A and AI literacy initiative for SMEs and citizens
- Accessibility standards: 5G-A device and service accessibility requirements for users with disabilities

8.3 Governance Roadmap

Action	Timeline	Deliverable
AI Regulatory Framework Development	Q1–Q3 2027	Published CITRA AI Policy for Telecommunications
Data Sovereignty Regulation	Q4 2026	Updated data localisation requirements for 5G-A operators
Cybersecurity Baseline	Q4 2026	NESAS adoption mandate published
Indoor Neutral Host License	Q3 2026	NHO license framework issued

3.8–4.1 GHz Licensing	Q4 2026	Spectrum awarded to operators for Phase 2 deployment
6G Innovation Fund	2028	Fund established, first research partnerships announced

Conclusion: Kuwait's Connectivity Leadership Imperative

Kuwait enters 2026 with an extraordinary foundation: the world's #1 5G ranking by adoption, 100% population coverage, and an active 5G-A commercial network. The question is no longer whether Kuwait can lead the global connectivity rankings — it is how to convert this foundation into declared, sustained, and measurable world leadership across four strategic dimensions.

> **Kuwait's Four Aspirations — The 2028 Vision**
>
> 01: World's First 10 Gbps Mobile Nation | 02: #1 Ookla Global Ranking | 03: 80% 5G-A Coverage — Indoor AND Outdoor | 04: 50%+ 5G-A Activated Users

The technical pathway is clear and the timeline is achievable. Phase 2 spectrum (3.8–4.1 GHz, 2026) delivers the 5 Gbps milestone and closes half the Ookla gap to UAE. The National Indoor 5G-A Program — with Tier 1 and Tier 2 venues deployed by end-2026 — closes the remaining speed gap and positions Kuwait for Ookla #1. Phase 3 spectrum (Upper 6 GHz, 2028) delivers the 10 Gbps commercial declaration. The user activation program, running in parallel, converts Kuwait's 4.12M 5G subscribers into 5G-A advocates.

The AI dimension amplifies everything. Kuwait's 5G-A network is not merely a connectivity infrastructure — it is the nervous system of an AI-enabled nation. AI smartphones, AI glasses, AI vehicles, and AI robots are already here, creating the demand profile that 5G-A was designed to serve. CITRA's forthcoming AI governance framework will ensure that Kuwait's network intelligence is developed responsibly, transparently, and in the interest of all citizens.

The path to 6G by 2030–2035 runs directly through 5G-A excellence. Nations that master 5G-A — its AI-native RAN, its indoor coverage completeness, its ecosystem integration — will be the nations that shape the 6G standard. Kuwait has every advantage to be among them.

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Appendix: Technical Glossary

Term	Definition
New Kuwait	Kuwait Vision 2035, branded "New Kuwait" — the State of Kuwait's national development plan launched January 2017, structured around seven strategic pillars and 164 programs, with a $193 billion active project pipeline. All seven pillars have direct dependencies on 5G-A and AI infrastructure
SCPD	Supreme Council for Planning and Development — the Kuwait government body chaired by the Prime Minister responsible for formulating and monitoring the Kuwait National Development Plans (KNDPs) that implement Vision 2035
BEL	Building Entry Loss — the signal attenuation (in dB) a radio wave experiences when penetrating a building exterior wall. BEL increases with frequency: 8–15 dB at 2.3 GHz; 10–18 dB at 2.6 GHz; 15–25 dB at 3.5 GHz (C-band). Source: 3GPP TR 38.901, ITU-R P.1238
O2I	Outdoor-to-Indoor — the propagation scenario where a mobile signal originates from an outdoor macrocell base station and must penetrate building structures to serve indoor users. 3GPP TR 38.901 defines O2I path loss models across all 5G frequency bands
5G-A	5G-Advanced — 3GPP Release 18+ enhancement adding AI-native RAN, multi-carrier aggregation, and XR optimization
2CC/3CC	Two/Three Carrier Aggregation — simultaneous use of 2 or 3 spectrum bands for multiplied data throughput
AI-RAN	AI-native Radio Access Network — mobile base station architecture with embedded machine learning (3GPP R18)
Ambient IoT	Batteryless IoT devices harvesting energy from ambient signals, standardized in 3GPP Release 18
Carrier Aggregation	Simultaneous use of multiple radio frequency bands to multiply data rates proportionally to spectrum width
C-band	3.4–4.2 GHz spectrum range — the primary 5G-A capacity band deployed by all three Kuwait operators
CITRA	Communication & Information Technology Regulatory Authority — Kuwait's telecom regulator
DAS	Distributed Antenna System — indoor signal distribution using antenna arrays connected to a central radio unit
F5G-A	Fixed 5th Generation Advanced — ETSI standard for next-generation fixed broadband evolution
IMT-2030	International Mobile Telecommunications 2030 — ITU-R framework defining 6G requirements and vision
MEC	Multi-Access Edge Computing — computing infrastructure co-located with radio networks for ultra-low latency

mmWave	Millimetre wave spectrum (24–100 GHz) — extremely high capacity, very short range, for dense environments
NESAS	Network Equipment Security Assurance Scheme — GSMA/3GPP security evaluation framework
NHO	Neutral Host Operator — a third-party entity providing shared indoor 5G-A infrastructure for multiple MNOs
NPU	Neural Processing Unit — dedicated AI compute chip in smartphones and XR devices for on-device AI inference
Ookla Speedtest	Global mobile network speed measurement index used as the international benchmark for network performance
RedCap	Reduced Capability — 3GPP R17/R18 device category for lower-cost IoT and wearable 5G devices
SA/NSA	Standalone/Non-Standalone — 5G core network deployment modes; SA uses dedicated 5G core, NSA reuses 4G core
TMForum	TeleManagement Forum — defines network autonomy levels L1–L5 for AI-driven network operations
U6GHz	Upper 6 GHz (6425–7125 MHz) — key 5G-A spectrum band for Phase 3 deployment, enabling 10 Gbps
URLLC	Ultra-Reliable Low Latency Communications — 5G service category for mission-critical applications
V2X	Vehicle-to-Everything — 5G-based communication standard connecting vehicles to infrastructure, pedestrians, and each other
XR	Extended Reality — umbrella term for Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR)